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FOSSIL RAILS (GRUIFORMES: RALLIDAE) FROM THE BALEARIC ISLANDS

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Resum

Es presenta el registre fòssil de rasclons de les Illes Balears. Aquest registre és peculiar per a cada una de les tres illes principals. A Mallorca consisteix en un ràl·lid petit indeterminat trobat a la Pedrera de s'Ònix (Manacor) i restes de *Porzana porzana* trobades al jaciment del Pleistocè superior – Holocè de la Cova de Moleta. A Menorca, les escasses restes disponibles provenen de dos dipòsits pleistocènics del nord de Ciutadella (Punta Esquitxador 12, Punta Esquitxador 17). A aquests dipòsits pleistocènics s'han identificat *Rallus* cf. *quaticus, Gallinula chloropus* i Rallidae indet. *Rallus* cf. *aquaticus* és l'espècie més abundant i els fòssils obtinguts són lleugerament més grossos que els ossos corresponents d'exemplars actuals de *Rallus aquaticus*. El ràl·lid indeterminat és un rascló de mida similar a la de *Porzana pusilla*, però que presenta alguns trets morfològics que l'apropen a *Rallus*. Només s'han exhumat tres ossos fragmentats d'aquest ràl·lid i la seva diagnosi taxonòmica resta sense resoldre. Es coneixen tres ràl·lids a partir de materials pel jaciment del Pleistocè superior d'Es Pouàs (Sant Antoni de Portmany, Eivissa, Illes Pitiüses). Un és *Crex crex*, una espècie present a altres dipòsits de la Mediterrània. El segon és una espècie nova, encara no descrita, que representa un parent insular del *Rallus aquaticus* del continent europeu. Es tracta del primer rascló insular endèmic de la regió mediterrània. Comparat amb el rascló europeu vivent, aquesta nova espècie era més petita i arrodonida, tenia les cames més curtes i robustes i les ales més curtes, amb una capacitat de vol presumptament reduïda. Les Pitiüses eren les úniques illes de la Mediterrània que durant el Pleistocè superior estaven mancades de mamífers terrestres i, sense cap dubte, aquesta absència ha d'estar relacionada amb l'evolució del rascló endèmic. La cronologia de l'extinció de *Rallus* n.sp. se solapa amplament amb la cronologia on se situa l'arribada dels humans, suggerint que existeix una relació entre aquests dos esdeveniments. El tercer ràl·lid fòssil d'Eivissa és *Porzana porzana*.

Paraules clau: *Rallus, Porzana*, Eivissa, Mallorca, Menorca, Late Pleistocene, Pliocene.

Abstract

The fossil record for rails from the Balearic Islands is presented in this paper. This record is highly distinctive for the three main islands. It consists in an indeterminate small rail from Pedrera de s'Ònix (Pliocene-Pleistocene boundary) and *Porzana porzana* in the Upper Pleistocene - Holocene deposit of Cova de Moleta on Mallorca. On Menorca the scarce available materials come from two Pleistocene deposits in Northern Ciutadella (Punta Esquitxador 12, Punta Esquitxador 17). *Rallus* cf. *aquaticus, Gallinula chloropus* and Rallidae indet. have been identified in these Pleistocene deposits. *Rallus* cf. *aquaticus* is the more abundant species and its obtained fossil material is slightly more robust than the current populations of *Rallus aquaticus*. The undetermined rallid is a rail similar in size to *Porzana pusilla*, but displaying some features close to *Rallus*. Only three fragmented bones of this rail have been exhumed, and their diagnosis remains unsolved. From the upper Pleistocene deposit of Es Pouàs (Sant Antoni de Portmany, Eivissa, Pityusic Islands), three rails are known. One of them is *Crex crex*, a species also present in other Mediterranean deposits. The second one is a new undescribed species of rail that represents an insular relative of the European rail *Rallus aquaticus*. It represents the first insular endemic rail from the Mediterranean region. Compared with the extant European rail, this new species was smaller and stouter, had shorter and more robust hind limbs and shorter wings, with presumed reduced flight ability. The Pityusics were the only Mediterranean islands with a vertebrate upper Pleistocene fauna without terrestrial mammals, and this absence is no doubt related with this Eivissan rail evolution. The chronology of the *Rallus* n.sp. extinction overlaps widely with the timing of the human arrival, suggesting a close relation between these two events. The third one is *Porzana porzana*, only present in low numbers.

Key words: *Rallus, Porzana*, Eivissa, Menorca, Mallorca, Late Pleistocene, Pliocene.

INTRODUCTION

On the Mediterranean Islands there is a small number of extant endemic bird species, mainly recruited within the Passeriformes (e.g., *Sylvia sarda, Sylvia balearica, Sylvia melanothorax, Oenanthe cypriaca, Sitta whiteheadi*) and Procellariiformes (*Puffinus yelkouan / mauretanicus*). The study of the fossils reveals that in the recent past the number of endemic species was considerably larger on the Mediterranean islands. Endemic recently disappeared species consist mainly in wing predators belonging to Accipitriformes (*Aquila*; Weesie, 1988; Louchart, 2002) and to Strigiformes (*Tyto, Athene, Bubo*; e.g., Weesie, 1982; Mourer-Chauviré & Weesie, 1986; Louchart, this volume).

In the last twenty years, the palaornithological exploration of the islands allowed to discover a clear evolutive pattern consisting in the presence of endemic rails in many islands of the world. Recent research allowed to discover a lot of insular endemic species of rails, and some of them have been described. Recent estimates suggest that several thousands of endemic species of rails could have inhabited the Pacific isolated islands. Insular living rails (Aves: Rallidae) are currently known from a small number of islands in the world (e.g., Galápagos, Guam, Okinawa, Inaccessible, New Zealand, Lord Howe). They are mainly recruited within *Gallirallus,* although other genera (e.g., *Porphyrio, Porzana, Amaurornis, Gallinula*) contain small numbers of insular species, and there are even several insular endemic genera (e.g., *Atlantisia, Nesoclopeus*). The increased palaeontological work of the last two decades has revealed that a huge number of insular endemic rails disappeared after the arrival of first human settlers into the islands (e.g., Steadman, 1991, 1995, 1997).

The biogeographic pattern discovered by palaeornithologists shows that rails are prone to evolve on islands originating endemic species or populations, and that the current diversity of insular rails merely reflects the survivals of a much larger past diversity. Several genera that currently do not include insular endemic species included some in the past (e.g., Olson, 1990; Steadman, 1995).

Up to the present, no endemic fossil rails have been described from the Mediterranean islands. Usually fossil insular endemic rails have been discovered on islands lacking of terrestrial mammals, and all the large Mediterranean islands, with a single exception, contains them. The goal of the present paper consists in to update the knowledge that we have on fossil rails of the Balearic Islands, as well as in to explore the insular evolution in the Mediterranean rails. The current record is relatively poor, and it will be presented here by islands.

Fossil record

On Mallorca, the fossil remains of rails are coming from two deposits. On Pedrera de s'Ònix (Manacor), a single tarsometatarsus reveals the presence of a small sized rail, probably a *Porzana* (Mourer-Chauviré, in Alcover et al., 1981). This material was associated to a rich bird fauna, with *Tyto balearica* as the most probable bioaccumulator agent. The estimate age of the fossil assemblage is the uppermost part of the Pliocene or the Plio-Pleistocene boundary, with an estimate palaeomagnetic age close to 1.8 My.

There is only another deposit on Mallorca that yielded rail bones: the Moleta cave (Sóller; Seguí *et al.*, 1997). This cave has been excavated at the sixties (see Waldren, 1982), and, unfortunately, it has many stratigraphic problems (see Ramis & Alcover, 2000; Alcover *et al.*, 2001),

Fig. 1. Map of the Western Mediterranean showing the location of Es Pouàs (Eivissa, Pityusic Islands).

***Fig. 1.** Mapa de la Mediterrània occidental que mostra la localització d'Es Pouàs (Eivissa, Illes Pitiüses).*

	Rallus n.sp.						*Rallus aquaticus*				
	Mean	min	max	n	sd		mean	min	max	n	sd
Humerus Length	35.26	32.44	37.94	18	1.58		38.87	34.97	42.10	35	1.73
Ulna Length	26.97	24.84	28.62	14	1.23		31.40	27.96	33.93	34	1.44
Carpometacarpus Length	18.53	15.89	20.85	13	1.66		21.49	19.37	23.31	33	1.00
Femur Length	37.23	34.23	40.77	13	2.02		41.38	37.56	44.76	36	2.00
Tibiotarsus Length	54.56	49.69	60.30	11	2.96		64.50	57.56	68.49	34	3.08
Tarsometatarsus Length	34.31	29.79	37.22	22	2.15		41.23	37.04	45.32	35	2.29

Table 1. Lengths (in mm) of selected skeletal elements of *Rallus* n.sp. from the Upper Pleistocene and Holocene of Eivissa and *Rallus aquaticus* (several localities). Mean, range (max and min), sample size (n) and standard deviation (sd) are indicated.

Taula 1. *Llargàries (en mm) d'elements esquelètics seleccionats de* Rallus *n.sp. del Pleistocè superior i Holocè d'Eivissa i de* Rallus aquaticus *(diferents localitats). S'indiquen la mitjana, l'espectre de mides (màxima i mínima), la mida de la mostra i la desviació típica.*

that involve some imprecision in the chronological position of the obtained fossils. Roughly, the cova de Moleta fossil materials are from Upper Pleistocene and Holocene. Six bones have been identified as belonging to *Porzana porzana.*

Two unpublished deposits from Menorca delivered a few rail fossil remains (Seguí, 1998). Both deposits are situated at the northern part of Ciutadella, at Punta Esquitxador. Two taxa have been specifically identified: *Rallus* cf. *aquaticus* and *Gallinula chloropus.* There are, additionally, several bones that are presented here as Rallidae unidentified genus and species. The bones of this unidentified taxon are of the size of *Porzana pusilla,* but they display some shared features with *Rallus aquaticus.* The identity of these bones currently remains unsolved.

Only one Eivissan deposit has delivered rail remains: Es Pouàs, an extraordinary fossiliferous deposit of the island, the larger of the Pityusic Islands (541 sq km), situated 90 km far from the Eastern Iberian Peninsula and about 80 km from Mallorca (see Fig. 1). The Pityusic archipelago consists in two main islands (Eivissa and Formentera) surrounded by about 60 small islets (Kuhbier 1984). Its biogeographic history reveals that they were, during the Upper Pleistocene and the Holocene (until the human arrival), the only territories in the whole Mediterranean area without terrestrial mammals (e.g., Florit *et al.* 1989; Alcover, *et al.,* 1994, 1999; Palmer *et al.,* 1999). This faunistic anomaly has been analysed by Seguí and Alcover (1999) who consider that the ecological parallels of the prehuman bird fauna from Eivissa may be found in some of the Pacific islands, like the Hawaiian Islands.

From Es Pouàs three species of Rallidae have been identified: the corncrake *Crex crex,* a still undescribed rail of genus *Rallus,* and *Porzana porzana.*

Crex crex is the most abundant rail species in the Pityusic fossil record. Some fossil specimens are slighly more robust that the studied bones of extant populations of the species. This slightly larger size fits well with a general size pattern documented in a great number of bird species. Nevertheless, it must be remarked than the scarcity of comparison material delimitates greatly a precise comparison. One of the fossil specimens (MNIB 30775) corresponds to an immature specimen, and consequently the breeding of the species on the island some time in the past shoud be deduced.

The very long and slender bill of the Eivissan species clearly places the smaller Eivissan rallid in the genus *Rallus* (Olson, 1973). This genus contains no insular living species, although two Pleistocene species have been recently described from Bermuda (Olson & Wingate, 2000, 2001) and a new undescribed species has been recorded from Miyakoshima, southern Ryukyu islands (Matsuoka, 2000, table 1), although the later could belong to *Gallirallus.* This is the only western Palaearctic Rallidae genus displaying this characteristic type of bill.

In addition to the shorter bill, this species has larger orbits. The fonticuli interorbitalis are larger than in *Rallus aquaticus.* There are no impressions for salt glands on the interorbital bridge, suggesting a life style independent of saline habitats.

The smaller fossil Eivissan rail differs from *Rallus aquaticus* and represents a new species of bird. It will be referred here as *Rallus* n.sp. Slightly smaller than *Rallus aquaticus,* the only species of the genus currently living in the Western Palaearctic and its presumably ancestor, *Rallus* n.sp. displays different proportions in the legs and body shape. Its wings are relatively smaller, suggesting some reduction in the development of the flight apparatus, although without achieving a flightless condition. Distal hindlimb elements are shorter and slightly more robust (see a comparison of bones of *Rallus* n.sp. from Eivissa and *Rallus aquaticus* in Fig. 2). Its body has a build which is shorter and relatively wider than in *Rallus aquaticus.* In relation to the size of the skull, the bill is slightly shorter than in *Rallus aquaticus.*

The available sternum of *Rallus* n.sp. is in a fragmentary state, but on the basis of the placement of the insertion of the trabecula lateralis in the corpus sterni, it is slightly shorter and wider than in *Rallus aquaticus.* Its carina is reduced, since the carina edge goes up following a smaller angle with the basis of the sternum, a good indicator for a lower carina. The carina reduction seems not achieve the degree recorded in the Bermudan species *Rallus ibycus* and *Rallus recessus,* the only other described insular species of the genus in the Northern Hemisphere (Olson & Wingate, 2000, 2001). Nevertheless, it seems to be indicative for a smaller size of the musculus supracoracoideus and musculus pectoralis, two muscles involved in the fight. All the wing bones are reduced, specially the carpometacarpus.

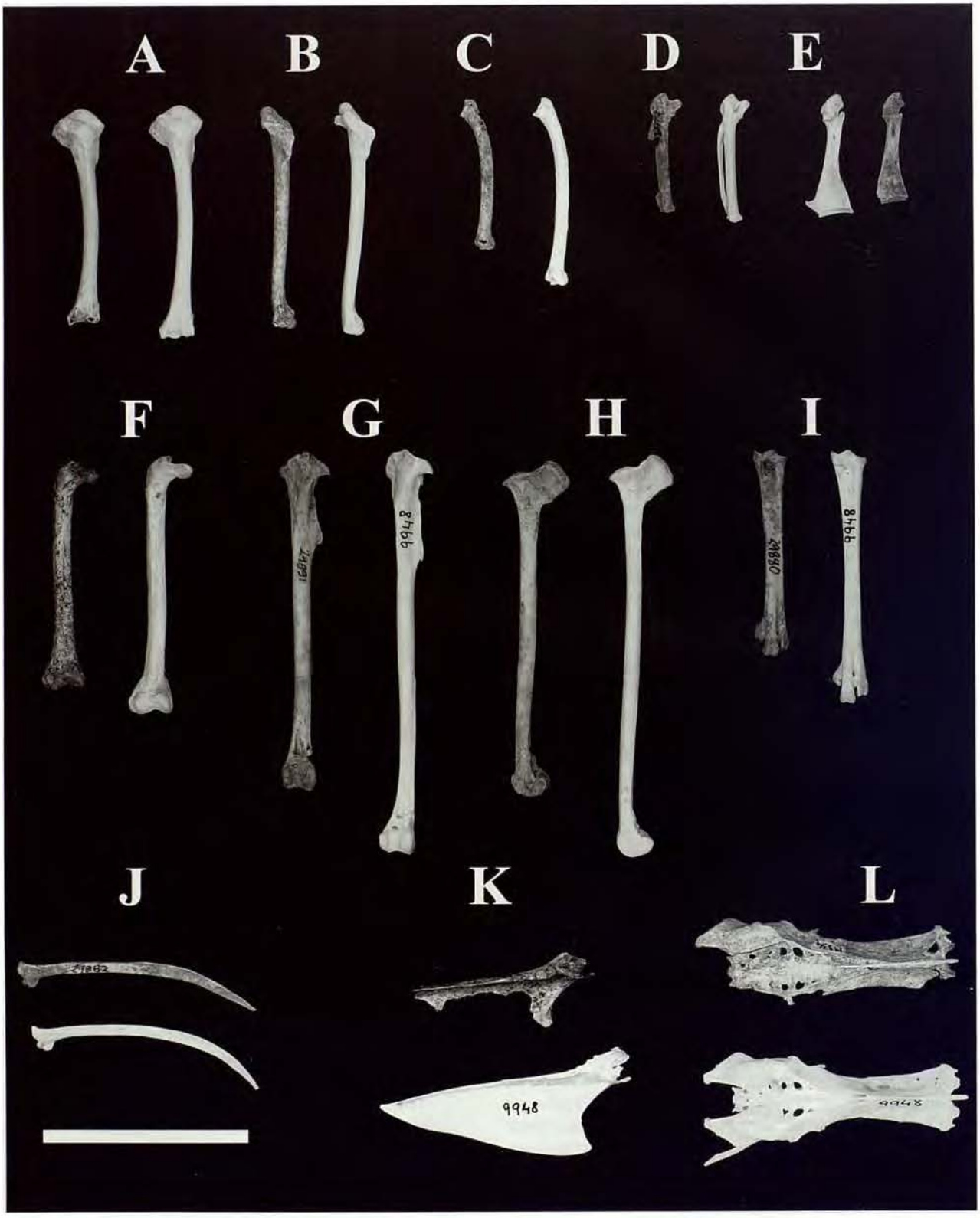

Fig. 2. Long bones of *Rallus* n.sp. in comparison with bones of *Rallus aquaticus* (MNIB 9948). A: Right humerus (MNIB 28624) in caudal view; B: Right humerus (MNIB 28624) in lateral view; C: Ulna MNIB 29870; D: Left carpometacarpus (MNIB 32496) in ventral view; E: Left coracoid (MNIB 29680) in caudal view; F: Left femur (MNIB 19818) in caudal view; G: Left tibiotarsus MNIB 29891) in cranial view; H: Left tibiotarsus (MNIB 29891) in lateral view; I: Left tarsometatarsus (holotype, MNIB 29880) in cranial view; J: Scapula (MNIB 29882) in ventromedial view; K: Sternum (MNIB 29881) in lateral view; L: Pelvis (MNIB 19334) in dorsal view. Scale 2 cm.

Fig. 2. Ossos llargs de Rallus *n.sp. en comparació amb ossos de* Rallus aquaticus *(MNIB 9948). A: Húmer dret (MNIB 28624) en norma caudal; B: Humer dret (MNIB 28624) en norma lateral; C: Ulna MNIB 29870; D: Carpometacarp esquerre (MNIB 32496) en norma ventral; E: Coracoid esquerre (MNIB 29680) en norma caudal; F: Fèmur esquerre (MNIB 19818) en norma caudal; G: Tibiotars esquerre (MNIB 29891) en norma cranial; H: Tibiotars esquerre (MNIB 29891) en norma lateral; I: Tarsometatars esquerre (MNIB 29880) en norma cranial; J: Escàpula (MNIB 29882) en norma ventromedial; K: Esternó (MNIB 29881) en norma lateral; L: Pelvis (MNIB 19334) en norma dorsal. Escala, 2 cm.*

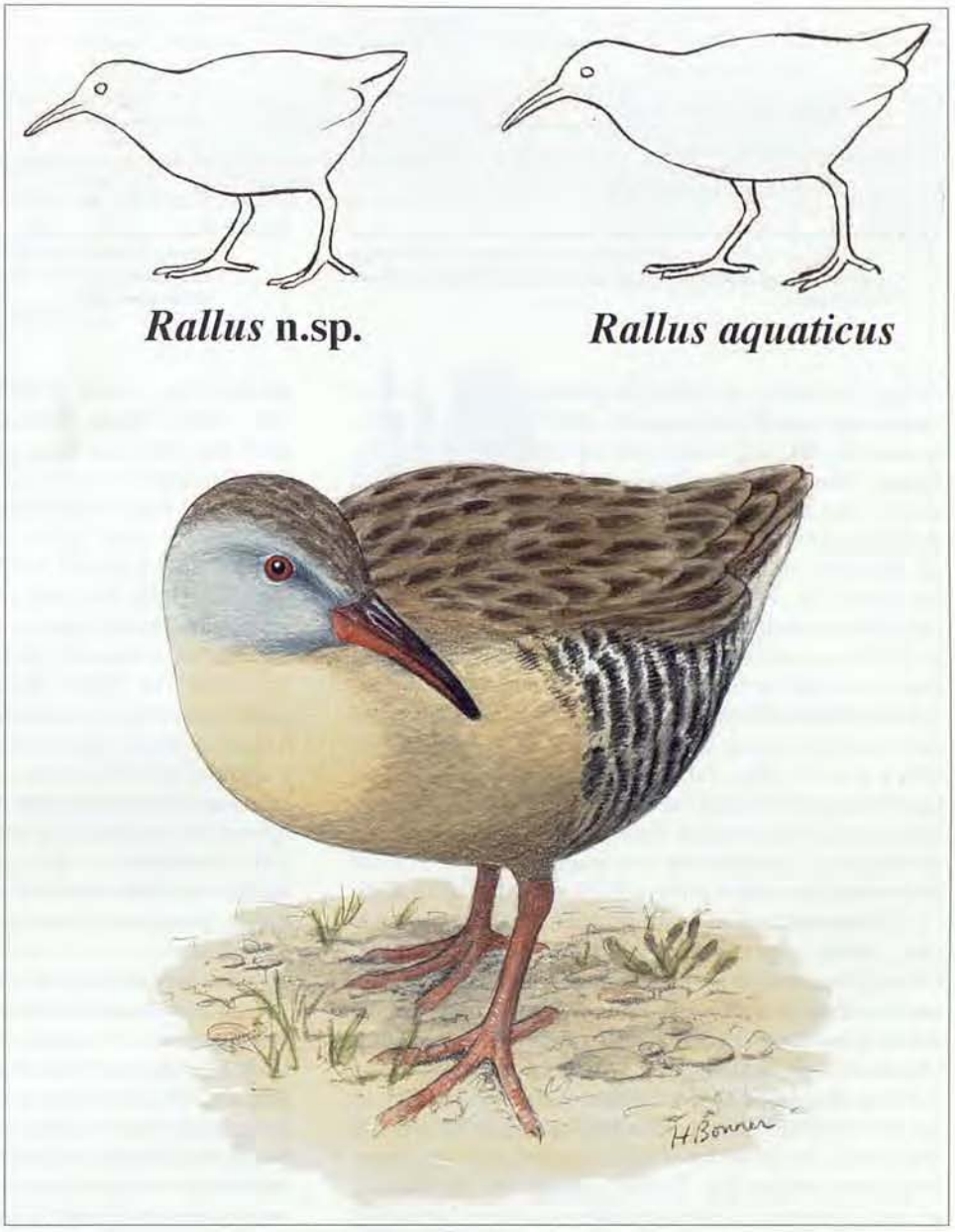

Fig. 3. An artistic reconstruction of *Rallus* n.sp. Author: Aina Bonner (Boston/Palma de Mallorca).

Fig. 3. Reconstrucció artística de Rallus *n.sp. Dibuix Aina Bonner (Palma de Mallorca/Boston).*

The two available pelvis are relatively robust, slightly wider and longer than in *Rallus aquaticus*. The hindlimb elements, specially the distal ones, are shorter and more robust.

Measurements of the long bones of *Rallus* n.sp. are presented in Table 1. A statistical comparison (ANCOVA) between the long bones of *Rallus* n.sp. and *R. aquaticus* using the General Linear Model (GLM) of the SYSTAT v.10 package has been performed. The total length and the shaft width have been used to characterise each long bone. Previously to the covariance analysis, the regression lines between the two measurements have been examined within each species and they were found significantly correlated. Independently of size, for any analysed length value, *Rallus* n.sp. shows proportionally higher values of shaft width than *Rallus aquaticus*. A non-isometrical reduction of the bones of *Rallus* n.sp. in comparison to those of *R. aquaticus* is clearly detected. This is due to a larger degree of shortening than of narrowing of the long bones. The shortening is larger at the distal bones, and more reduced at the proximal ones. As a mean, the humerus length reduction is about 9%, the ulna shortening is about 14% and the carpometacarpus shortening achieves about 17%. In the hindlimb, the femora length reduction is about 10%, the tibiotarsus shortening is about 15% while the tarsometatarsus shortening achieves about 17%. All the length measurements present significant differences ($p < 0.05$) between both species. The tarsometatarsus represents the only long bone displaying an actually wider shaft in *Rallus* n.sp. in comparison to *R. aquaticus*. The stouter configuration of the tarsometatarsus together with its highest displayed shortening gives to this bone the most peculiar shape. An artistic reconstruction of the animal is presented in Fig. 3. Although body proportions are accurately presented, the coloration is a subjective approach based on extant relatives.

The new rail species spread over the Late Pleistoce-

	Mean	xmin	xmax	n	sd
Humerus length	41.61	35.42	45.41	14	2.849
Carpometacarpus length	26.31	26.05	26.51	6	0.174
Femur Length	45.85			1	
Tarsometatarsus length	37.43	35.94	38.75	8	0.859

Table 2. Lengths (in mm) of selected skeletal elements of *Crex crex* from the Upper Pleistocene and Holocene of Eivissa . Mean, range (max and min), sample size (n) and standard deviation (sd) are indicated.

Taula 2. *Llargàries (en mm) d'elements esquelètics seleccionats de* Crex crex *del Pleistocè superior i Holocè d'Eivissa. S'indiquen la mitjana, l'espectre de mides (màxima i mínima), la mida de la mostra i la desviació típica.*

ne and the Holocene. A distal fragment of a tibiotarsus of *Rallus* n.sp. was directly dated by AMS C14 (MNIB 19979, square D4, UtC 6222: 6130 ± 80 BP, 5300-4840 calBC 2σ; Fig. 4). The lowermost level (square A3, level 7) from where *Rallus* n.sp. bones has been obtained, furnished the dating UtC-6674: 23030±150 BP; 21400-20750 cal BC 2σ. The level immediately above this (level 6), furnished the dating UtC-6673: 16170±90 BP; 18000-16700 cal BC 2σ. All these datings were performed on bone collagen, and all the analytical steps went correctly. Given than the levels were defined as constituted by successive sublevels, and than no indication to what sublevel belongs the dated samples, these datings only allow us to document with a p > 95% that the species was living in Eivissa at least between 5300 and 16700 calBC. Although this is the isotopically documented known age range, there are stratigraphical evidence of later materials, and no doubt exists about its earlier presence.

The assessment of relationships of the new species is clear. *Rallus* n.sp. is a close relative to *Rallus aquaticus*, the only species of the genus currently present in the western Palaearctic region. Both species share not only the long and slender bill, but also a large number of other characteristics. Actually, they differ only in the characters that can be related to a reduction of the flight ability, to the size of hindlimb bones and to the proportions of the legs. Given the presence of *Rallus aquaticus* in the European fossil record (e.g., Tyrberg, 1998), and the existing shared characters, it is reasonable to assume that *Rallus n.sp.* is an insular derivative from *Rallus aquaticus*. No comparison has been made with the sub-Saharan species *Rallus caerulescens* and the Malagasian species *Rallus madagascarensis*, the only other two species of *Rallus* from the Old World, but according to the available external measurements both are larger than *R. aquaticus* (Taylor, 1996). No direct relationships with these two species are expected.

The studied sample of *Rallus aquaticus* reasonably includes the variation range of the species. No differences between the recent insular sample of Mallorca and the mainland specimens have been detected. Although a study of the variation of this species along all its distribution range is not available, no great differences are expected between the different populations of this species. The four recognized subspecies of *R. aquaticus* are separated on plumage (Taylor, 1996), and no size differences between them have been ever quoted.

No data exists about the timing of the divergence between *Rallus* n.sp. and its assumed ancestor, *R. aquaticus*. The palaeontological record from Eivissa is discontinuous (e.g., Agustí & Moyà Solà, 1990; Alcover *et al.*, 1981, 1994). Some Pliocene/Lower Pleistocene (sensu latu) deposits have been recorded (e.g., Cova de ca na Reia, Pedrera de can Besora, Cala Salada). They delivered an insular fauna containing rodents (Alcover & Agustí 1985; Alcover *et al.*, 2000a, 2000b), a giant tortoise (Bour 1985; Gàsser & Ferrer, 1997; Filella *et al.*, 1999), a lizard (Kotsakis 1981), bats and birds (Alcover 1989), as well as a land molluscan fauna including between 17 and 21 taxa (Gasull & Alcover, 1982; Paul, 1982 1984; Paul & Altaba, 1992). The Upper Pleistocene and Holocene fauna lacks of terrestrial mammals, tortoises and contains only 6 land molluscs. Nevertheless, this fauna contains huge quantities of birds (Florit *et al.*, 1989). Between the later fauna and the former one it is a fossiliferous hiatus that spread over hundreds of thousands years (Alcover *et al.*, 1994). Probably the divergence of an insular species of *Rallus* started in an indeterminate time within this hiatus. A postglacial divergence cannot definitively be excluded.

The general body shape of *Rallus* n.sp. differs from that of *Rallus aquaticus* in the same way, but in an smaller degree, that *R. recessus* differs from *Rallus elegans*. Its body was slightly wider than that of *R. aquaticus*. The shape of the tarsometatarsus suggests a proportionally heavy body. In life, *Rallus* n.sp. should have had a plumper body, in spite of the sternum carina reduction. Its hindlimbs were shorter and more robust, and its wings were relatively shorter. Such combination of characters suggests a more terrestrial life-style for *Rallus* n.sp., including a reduced flight ability, although there is no evidence for complete flightlessness.

The species bred in Eivissa, as can be deduced from the presence of several juvenile bones in the fossiliferous record (e.g., humeri MNIB 19183, 19487, 23303, 28626, 29703, sinsacrum MNIB 29677, tibiotarsi MNIB 29468, 29859). Although *Rallus aquaticus*, its presumably ancestor, is partially migratory, a migratory condition for *Rallus* n.sp. can be ruled out on the basis of its assumed reduced flight ability, and we believe that *Rallus* n.sp. lived exclusively in the Pityusic Islands. Consequently, its distribution range must to have been small, and it probably consisted in some patches of suitable habitats in the Pityusics. Although its ecology is widely unknown, its reduced potential distribution area and the size of the obtained sample (161 identified bones within an estimation of >120.000 bird bones obtained in Es Pouàs) suggest that the Pityusics actually supported a small population size for *Rallus* n.sp.

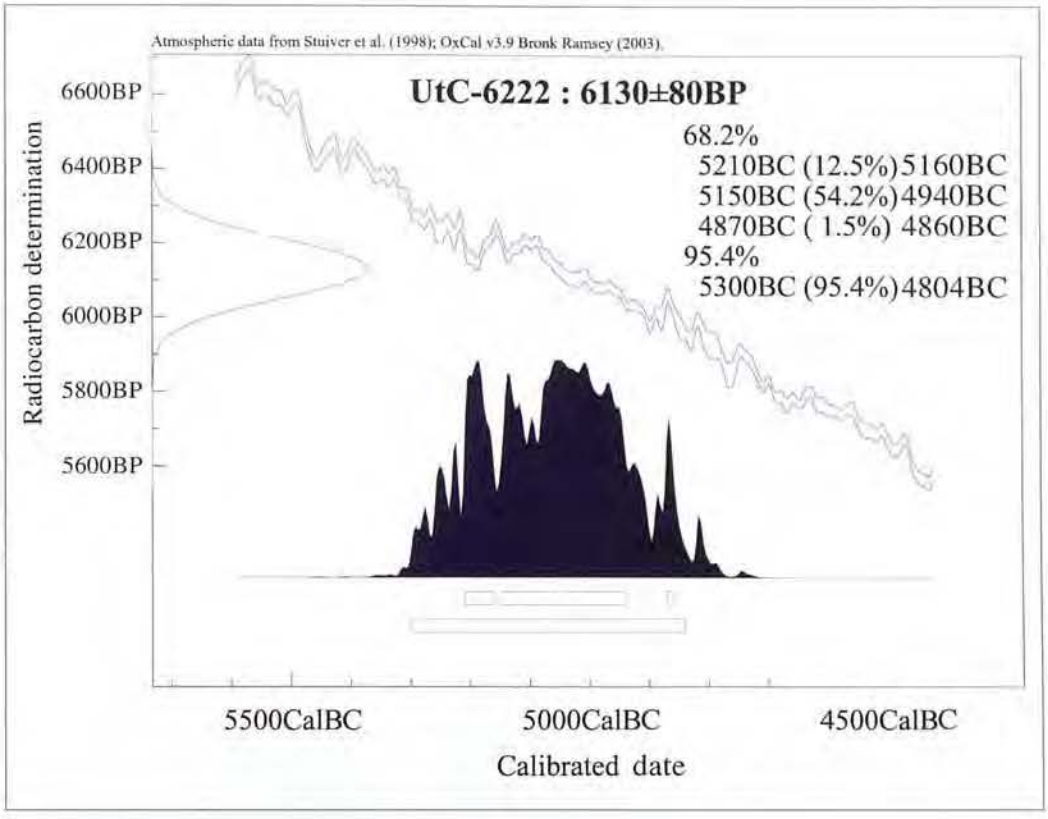

Fig. 4. Corba de calibratge de la datació UtC-6222, que documenta la presència més recent coneguda de *Rallus* n.sp. a Eivissa.

Fig. 4. Calibration curve for the UtC-6222, which records the most recent available evidence for Rallus *n.sp. on Eivissa.*

Rallus n.sp. represents the first endemic species from the Pityusic islands that became extinct in recent times. The more recent evidence for its presence post-dates, with a p > 95 %, 5300 cal BC. The evidence of human presence on the island pre-dates 1880 cal BC, with a p > 95%. The close timing of the human arrival into the Pityusics (Alcover *et al.*, 2001) as well as the proneness of the insular rail species to became extinct after the human arrival suggests strongly that its disappearance can be related to the first human arrival. Its reduced flight ability and its presumed small population size probably strongly influenced on its extinction proccess.

Finally, the third species of rail present in the Pityusic fossil record is *Porzana porzana*. The fossil record consists exclusively in seven bones: tree humeri, three carpometacarpi and one tarsometatarsus. Their morphology and size is similar to that of the extant specimens.

Conclusion

The fossil record of rails from the Balearic Islands is scarce. The fossil rail fauna is related with the extant one, and have a clear Mediterranean character. The finding of a new species of rail recently extinct in Eivissa, derived from *Rallus aquaticus*, emerges as a new singularity of the single Mediterranean insular fauna without terrestrial mammals. The extinction of *Rallus* n.sp. is the sole recent documented Holocene bird extinction at the Balearics.

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